

# Space Radiation Program Element

Human Adaptation and Countermeasures Office

<http://nsoa.jsc.nasa.gov>

Space Radiation Health Project

THE SPACE RADIATION HEALTH PROJECT

The purpose of NASA's Space Radiation Health Project is to provide human exploration without exceeding an acceptable level of risk from space radiation exposure. Human effects from space radiation are an important safety concern of long-term space travel. These health risks include cancer, damage to the central nervous system, degenerative diseases, such as heart disease, and acute radiation syndrome. These health risks must be understood and reduced in order for successful future missions to continue.

When a space flyer is exposed to space radiation, the effects can be categorized into three main groups: Acute Radiation Syndrome (ARS), Degenerative Diseases (DD), and Cancer. ARS is the most immediate and severe effect, occurring within hours of exposure. DD are long-term effects that develop over years or decades. Cancer is a long-term effect that can develop many years after exposure.

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SPACE RADIATION HEALTH RISKS

The harmful biological effects of ionizing radiation (IR) pose a significant and secondary problem and concern for the human exploration. Current NASA research is focused on understanding the biological effects of IR. NASA has defined the IR health concerns for humans in space radiation as:

- Carcinogenesis:** Increased cancer morbidity or mortality rate in astronauts may be linked by occupational activities exposure.
- Central Nervous System Disease:** Acute and late radiation damage to the central nervous system (CNS) may lead to changes in major function and behavior or neurological disorders.
- Degenerative Tissue Effects:** Radiation exposure may result in degenerative tissue alterations (cardiac or eye CNS) such as cataracts, osteoporosis, or degenerative diseases.
- Acute Radiation Syndrome:** Acute radiation syndrome may occur due to overexposure to radiation exposure.

SPACE RADIATION HEALTH LABORATORIES

**Loma Linda Lab:** The Loma Linda University (LLU) Proton Therapy Center is the first proton facility in the world designed for proton beam therapy and research. Proton radiation therapy allows the physical effects of the radiation beam to be precisely in the target, thereby reducing the damage to healthy tissue.

**Birmingham Lab:** The purpose of the NASA Space Radiation Laboratory is to provide human exploration without exceeding an acceptable level of risk from space radiation exposure. Human effects from space radiation are an important safety concern of long-term space travel. These health risks include cancer, damage to the central nervous system, degenerative diseases, such as heart disease, and acute radiation syndrome. These health risks must be understood and reduced in order for successful future missions to continue.

- ## Requirements
- Develop and Validate Standards**
    - By performing research to inform the development and validation of Space Radiation Permissible Exposure Limits for
      - Radiation Carcinogenesis
      - Acute Radiation Syndromes
      - Acute or Late Central Nervous System Effects
      - Degenerative Tissue Effects
  - Quantify Space Radiation Human Health Risks**
    - By developing validated mechanisms, models and methods to quantify the risk of Radiation Carcinogenesis and Acute Radiation Syndromes for Exploration Missions
    - By performing the research necessary to develop an evidence base for radiation induced Acute or Late Central Nervous System Effects and Degenerative Tissue Effects
    - By identifying whether synergistic effects from other spaceflight factors modify radiation health risks
  - Mitigate Risks thru Countermeasures & Technologies**
    - By developing tools and methodologies to evaluate shielding approaches and vehicle requirements for mission planning and design
    - By performing the research necessary to develop and validate biomedical or dietary countermeasures for radiation carcinogenesis and other risks quantified as significantly high
  - Treat and Monitor Unmitigated Risks**
    - By developing tools to assess and monitor compliance with the Space Radiation Permissible Exposure Limits
    - By developing biosensor and biomarker technologies for radiation carcinogenesis and other risks quantified as significantly high
    - By developing in-flight physical detector technologies through TRL 4 to monitor compliance with the Space Radiation Permissible Exposure Limits
    - By supporting the transition of research deliverables to technology maturation and operational programs



### Cancer Gaps

1.1.1.1	What are the probabilities for the occurrence of cancer in space? (Cancer is a complex phenomenon, and the probabilities for the occurrence of cancer in space are not known.)
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## Schedule Overview

Agency Mission	2006-2013	2014-2016	2017-2024	Contributions to the Mission
Lunar Surface Missions by 2013	Perform research on lunar surface effects of space radiation, including the effects of solar and galactic cosmic rays, and the effects of secondary particles.	Validate radiation models and transport models using lunar surface data, and the effects of secondary particles.	Develop and deploy an experimental, integrated system for monitoring space radiation, including the effects of solar and galactic cosmic rays, and the effects of secondary particles.	Contribute to the mission by providing data on the effects of space radiation, including the effects of solar and galactic cosmic rays, and the effects of secondary particles.
Lunar outpost Missions up to 240 days	Use TRL 3 to simulate space radiation for lunar surface and lunar atmosphere, and the effects of secondary particles.	Complete TRL 3 research on lunar surface and lunar atmosphere, and the effects of secondary particles.	Complete TRL 3 research on lunar surface and lunar atmosphere, and the effects of secondary particles.	Design and develop an experimental, integrated system for monitoring space radiation, including the effects of solar and galactic cosmic rays, and the effects of secondary particles.
Mars Exploration Missions by 2030	Use TRL 3 to simulate space radiation for Mars surface and Mars atmosphere, and the effects of secondary particles.	Complete TRL 3 research on Mars surface and Mars atmosphere, and the effects of secondary particles.	Complete TRL 3 research on Mars surface and Mars atmosphere, and the effects of secondary particles.	Design and develop an experimental, integrated system for monitoring space radiation, including the effects of solar and galactic cosmic rays, and the effects of secondary particles.